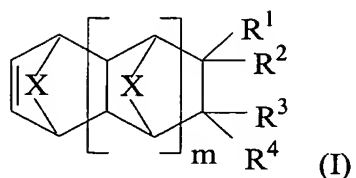


WE CLAIM:

1. A method of polymerizing poly(cyclic)olefin monomers comprising:
 - (a) combining a monomer composition comprising one or more poly(cyclic)olefin monomers, a non-olefinic chain transfer agent and an optional activator compound in a reaction vessel to form a mixture; and
 - (b) adding a polymerization catalyst containing Ni and/or Pd, the catalyst causing the mixture to polymerize;wherein the non-olefinic chain transfer agent includes one or more compounds selected from the group consisting of H₂, alkylsilanes, alkylalkoxysilanes, alkylgermanes, alkylalkoxygermanes, alkylstannanes, and alkylalkoxystannanes.
2. The method of claim 1, wherein the non-olefinic chain transfer agent comprises alkylsilanes and/or alkylalkoxysilanes.
3. The method of claim 1, wherein the non-olefinic chain transfer agent comprises H₂.
4. The method of claim 1, wherein an activator is present and the activator is characterized as having a functional group containing an active hydrogen with a pKa of at least about 5.
5. The method of claim 4, wherein the functional group is hydroxyl or carboxylic acid.
6. The method of claim 4, wherein the functional group is –OH.
7. The method of claim 4, wherein the activator is a compound containing an –OH functional group selected from water and C₁-C₂₄ linear, branched, and cyclic alkyl, aryl, and alkaryl moieties containing at least one hydroxyl group.

8. The method of claim 1, wherein the poly(cyclic)olefin monomers comprise a first monomer according to Formula (I):



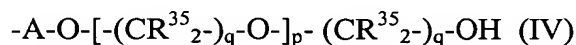
wherein X is selected from O, S, -NH-, -CH₂-, and -CH₂-CH₂-; m is an integer from 0 to 5; and each occurrence of R¹, R², R³ and R⁴ is independently selected from one of the following groups:

a) H, halogen, linear, branched or cyclic C₁ to C₃₀ alkyl, aryl, aralkyl, alkaryl, alkenyl or alkynyl;

b) linear or branched C₁ to C₂₄ halohydrocarbyls, -(CH₂)_nC(O)OR*, -(CH₂)_nC(O)OR', -(CH₂)_nOR, -(CH₂)_nOC(O)R, -(CH₂)_nC(O)R, -(CH₂)_n-OC(O)OR', -(CH₂)_nC(R)₂CH(R)(C(O)OR**), -(CH₂)_n(CR₂)_nCH(R)(C(O)OR**), -(CH₂)_nC(OR***)(CF₃)₂, -(CR''₂)_nOR, -CH₂-[O(CH₂)_n]_{m*}-C(OR***)(CF₃)₂, -(CH₂)_nC(R)₂CH(C(O)OR**) ₂, -(CH₂)_nC(O)OH, CH₂)_nC(R*)₂CH(R*)(C(O)OH), -(CH₂)_n-C(O)-O-R¹⁸, -(CH₂)_n-C(CY₃)₂-OH, and -(CH₂)_nC(R*)₂CH(C(O)OH)₂; where each occurrence of R is independently selected from H and linear or branched C₁ to C₁₀ alkyl; R' is a linear or branched C₁ to C₁₀ alkyl or alkylol; R'' is selected from H and halogen; n and m* are each an integer from 0 to 10; R* represents an acid labile group cleavable by a photoacid generator; R** is selected from R' and R* as defined above and tertiary C₄ to C₂₀ alkyl and cycloalkyl, C₁ to C₆ trialkylsilyl groups, and C₄ to C₂₀ oxoalkyl; R*** is selected from H, -CH₂OR''', -C(O)OR''' and -C(O)R''', where R''' is selected from methyl, ethyl, t-butyl, and C₁ to C₂₀ linear or branched cycloaliphatic, R¹⁸ is selected from H, and linear, branched or cyclic C₁-C₂₄ alkyl, aryl, aralkyl, and alkaryl, Y is selected from F and Cl and at least one occurrence of Y is F;

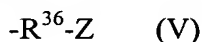
c) C₁ to C₃₀ linear, branched, or cyclic alkyl, aryl, aralkyl, alkaryl, alkenyl or alkynyl containing one or more hetero atoms selected from O, N, and Si;

d) a hydroxy alkyl ether according to Formula (IV):



wherein A is a linking group selected from C₁ to C₆ linear, branched, or cyclic alkylene, each occurrence of R³⁵ is independently selected from H, methyl, ethyl and a halide, q is from 1 to 5, and p is from 0 to 3;

e) a group according to Formula (V):



where R³⁶ is a linear, branched or cyclic C₁ to C₃₀, optionally partially or completely halogenated, alkylene, arylene, aralkylene, alkarylene, alkenylene or alkynylene linking group and Z is a functional group selected from hydroxyl, carboxylic acid, amine, thiol, isocyanate and epoxy; and

f) C_rX["]_{2r+1}, wherein X["] is independently a halogen selected from fluorine, chlorine, bromine or iodine and r is an integer from 1 to 20.

9. The method of claim 8, wherein m=0.

10. The method of claim 8, wherein m=0, R¹ is the hydroxy alkyl ether according to Formula (IV), and R², R³, and R⁴ are each H in the poly(cyclic)olefin monomer.

11. The method of claim 8, wherein A is methylene or ethylene, each occurrence of R³⁵ is H, q is from 2 to 5, and p is 0 in the poly(cyclic)olefin monomer.

12. The method of claim 8, wherein m=0, X is -CH₂-, R¹, R² and R³ are hydrogen, and R⁴ is -(CH₂)_n-C(OR^{***})-(CF₃)₂ where n and R^{***} is as defined above.

13. The method of claim 8, wherein m=0, X is -CH₂-, R¹ and R² are hydrogen and R³ and R⁴ are C_rX["]_{2r+1}, wherein X["] is independently a halogen selected from fluorine, chlorine, bromine or iodine and r is an integer from 1 to 20.

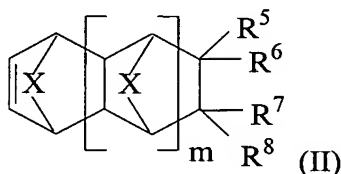
14. The method of claim 1, wherein the poly(cyclic)olefin monomer is selected from the group consisting of

α,α -bis(trifluoromethyl)bicyclo[2.2.1]hept-5-ene-2-ethanol, 5-norbornene-2-methanol hydroxyethyl ether, t-butyl ester of norbornene 5-carboxylic acid, hydroxyethyl ester of 5-norbornene carboxylic acid, trimethylsilane ester of 5-norbornene carboxylic acid, 5-norbornene-2-methanol acetate, 5-norbornene-2-methanol, 5-norbornene-2-ethanol, 5-triethoxysilylnorbornene, 1-methylcyclopentyl ester of 5-norbornene carboxylic acid, tetrahydro-2-oxo-3-furanyl ester of 5-norbornene carboxylic acid, and mixtures thereof.

15. The method of claim 8, wherein the acid labile groups, denoted R^* , in the poly(cyclic)olefin monomer are selected from the group consisting of $-C(CH_3)_3$, $-Si(CH_3)_3$, isobornyl, 2-methyl-2-adamantyl, tetrahydrofuranyl, tetrahydropyranoyl, 3-oxocyclohexanonyl, mevalonic lactonyl, dicyclopropylmethyl, dimethylcyclopropylmethyl and mixtures thereof.

16. The method of claim 8, wherein R^{**} in the poly(cyclic)olefin monomer is selected from the group consisting of tert-butyl, tert-amyl, 1,1-diethylpropyl, 1-methylcyclopentyl, 1-ethylcyclopentyl, 1-butylcyclopentyl, 1-methylcyclohexyl, 1-ethylcyclohexyl, 1-butylcyclohexyl, 1-ethyl-2-cyclopentenyl, 1-ethyl-2-cyclohexenyl, 2-ethyl-2-adamantyl, trimethylsilyl, triethylsilyl and dimethyl-tert-butylysilyl, 3-oxocyclohexyl, 4-methyl-2-oxooxan-4-yl, and 5-methyl-2-oxooxolan-5-yl.

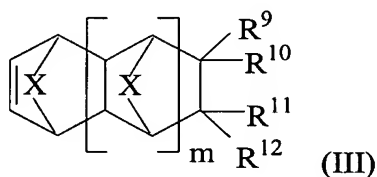
17. The method of claim 8, wherein the poly(cyclic)olefin monomers further comprise a second monomer according to Formula (II):



wherein m is an integer from 0 to 5; X is selected from $-CH_2-$, $-CH_2-CH_2-$, O, S, and $-NH-$; R^5 to R^8 are independently selected from H, $-(CH_2)_n-C(O)OR''$, $-(CH_2)_n-OR'$, $Si(OR')_3$, $-(CB_2)_n-OC(O)R''$, $-(CH_2)_n-OC(O)OR''$, $-(CH_2)_n-C(O)R'$, $-(CH_2)_nC(R^*)_2CH(R^*)(C(O)OR^{**})$, $-(CH_2)_nC(R^*)_2CH(C(O)OR^{**})_2$,

-C(O)O-(CH₂)_n-OR' and -(CH₂)_n-O-(CH₂)_n-OR', wherein n is independently an integer from 0 to 10; B is hydrogen or a halogen; R* and R are independently hydrogen, a halogen, C₁ to C₁₀ linear or branched alkyl or cycloalkyl, or C₁ to C₁₀ linear or branched halogenated alkyl or cycloalkyl; R** is independently C₁ to C₁₀ linear or branched alkyl or cycloalkyl or C₁ to C₁₀ linear or branched halogenated alkyl cycloalkyl; and R" is independently C₁ to C₁₀ linear or branched alkyl or halogenated alkyl, C₄ to C₂₀ monocyclic or polycyclic cycloaliphatic or halogenated cycloalkyl moiety, a cyclic ether, a cyclic ketone or a cyclic ester (lactone), wherein each of the cyclic ether, ketone and ester can be halogenated or not.

18. The method of claim 17, wherein $m=0$ in the second monomer.
19. The method of claim 17, wherein the cycloaliphatic groups of R are selected from the group consisting of cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, 1-adamantyl, and 1-norbornene.
20. The method of claim 17, wherein the groups R^1 to R^4 and R^5 to R^8 in the poly(cyclic)olefin monomers of Formula (I) and Formula (II) are independently selected such that three or more poly(cyclic)olefin monomers are included in the monomer composition.
21. The method of claim 8, wherein the poly(cyclic)olefin monomers further comprise a third monomer according to Formula (III):



wherein m is an integer from 0 to 5; X is $-\text{CH}_2-$, $-\text{CH}_2\text{CH}_2-$, O, S, or $-\text{NH}-$; R^9 to R^{12} are independently selected from H, halogen, linear, branched or cyclic C_1 to C_{30} alkyl, alkylol, aryl, aralkyl, alkaryl, alkenyl or alkynyl; a non-carboxylic acid group containing

an active hydrogen with a pKa of 15 or less, and a carboxylic acid substituents selected from the group consisting of those in accordance with the formulas $-(CH_2)_qC(O)OH$, $(CH_2)_qC(R^{25})_2CH(R^{25})(C(O)OH)$ or $-(CH_2)_qC(R^{25})_2CH(C(O)OH)_2$, wherein q is an integer from 0 to 10 and each occurrence of R^{25} is independently selected from H, halogen, linear, branched or cyclic C_1 to C_{10} alkyl, and linear, branched or cyclic C_1 to C_{10} halogenated alkyl; and wherein at least one of R^9 to R^{12} is a carboxylic acid substituent as described above.

22. The method of claim 21, wherein $m=0$ in the third monomer.

23. The method of claim 21, wherein the groups R^1 to R^4 and R^9 to R^{12} in the poly(cyclic)olefin monomers of Formula (I) and Formula (III) are independently selected such that three or more poly(cyclic)olefin monomers are included in the monomer composition.

24. The method of claim 1, wherein the chain transfer agent is one or more of an alkylsilane or alkylalkoxysilane selected from the group consisting of Si-H containing cyclotetrasiloxanes and compounds according to the formulae $HSiR^{48}_3$, $HSi(OR^{48})_1R^{48}_2$, $HSi(OR^{48})_2R^{48}_1$, $Si(OSiR^{49}_3)_4$, and mixtures thereof, wherein each occurrence of R^{48} is independently selected from linear, branched or cyclic C_1 to C_{10} alkyl and each occurrence of R^{49} is independently selected from H and linear, branched or cyclic C_1 to C_{10} alkyl, where at least one occurrence of R^{49} is H.

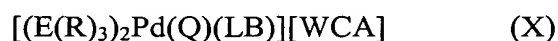
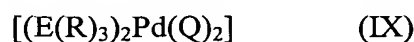
25. The method of claim 24, wherein the alkylsilanes are selected from the group consisting of triethylsilane, tri-isopropylsilane, and mixtures thereof.

26. The method of claim 1, wherein the combination of the monomer composition and catalyst is heated a temperature sufficient to effect polymerization.

27. The method of claim 26, wherein the mixture is heated to a temperature of from 30 to 150°C.

28. The method of claim 1, wherein the polymerization catalyst comprises Pd.

29. The method of claim 1, wherein the polymerization catalyst comprises a catalyst according to one or both of Formulae (IX) and (X):



wherein E is a Group 15 element from the Periodic Table of the Elements, R independently represents hydrogen or an anionic hydrocarbyl containing moiety; Q represents an anionic ligand selected from a carboxylate, thiocarboxylate, and dithiocarboxylate group; LB represents a Lewis base; WCA represents a weakly coordinating anion.

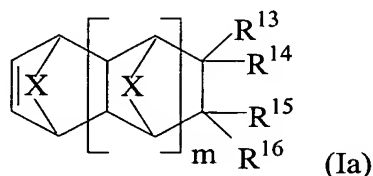
30. The method of claim 1, wherein the polymerization catalyst is selected from the group consisting of *trans*-[Pd(NCMe)(OAc)(P(*i*-propyl)₃)₂]B(C₆F₅)₄, *trans*-[Pd(NCC(CH₃)₃)(OAc)(P(*i*-propyl)₃)₂]B(C₆F₅)₄, *trans*-[Pd(OC(C₆H₅)₂)(OAc)(P(*i*-propyl)₃)₂]B(C₆F₅)₄, *trans*-[Pd(HOCH(CH₃)₂)(OAc)(P(*i*-propyl)₃)₂]B(C₆F₅)₄, *trans*-[Pd(NCMe)(OAc)(P(cyclohexyl)₃)₂]B(C₆F₅)₄, Pd(OAc)₂(P(cyclohexyl)₃)₂, Pd(OAc)₂(P(*i*-propyl)₃)₂, Pd(OAc)₂(P(*i*-propyl)₂(phenyl))₂, *trans*-[Pd(NCMe)(OAc)(P(cyclohexyl)₂(*t*-butyl))₂]B(C₆F₅)₄ and mixtures thereof.

31. The method of claim 1, wherein the polymerization catalyst comprises Ni.

32. The method of claim 1, wherein the molar ratio of monomer to catalyst is from 200:1 to 200,000:1.

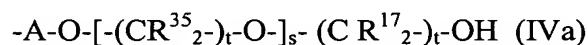
33. A poly(cyclic)olefin polymer prepared according to the method of claim 1.

34. A poly(cyclic)olefin polymer prepared according to the method of claim 8.
35. A poly(cyclic)olefin polymer prepared according to the method of claim 17.
36. A poly(cyclic)olefin polymer prepared according to the method of claim 21.
37. An unsaturated monomer comprising Formula (Ia):



wherein X is selected from $-\text{CH}_2-$, $-\text{CH}_2\text{-CH}_2-$, O, S and $-\text{NH}-$; m is an integer from 0 to 5; and each occurrence of R^{13} , R^{14} , R^{15} and R^{16} are independently selected from one of the following groups:

- (a) H, C_1 to C_{25} linear, branched, and cyclic alkyl, aryl, aralkyl, alkaryl, alkenyl and alkynyl;
- (b) C_1 to C_{25} linear, branched, and cyclic alkyl, aryl, aralkyl, alkaryl, alkenyl and alkynyl containing one or more hetero atoms selected from O, N, and Si;
- (c) a hydroxy alkyl ether according to Formula (IVa):



wherein A is a linking group selected from C_1 to C_6 linear, branched, and cyclic alkylene, each occurrence of R^{17} is independently selected from H, methyl and ethyl, R^{35} is independently selected from H, methyl, ethyl and a halide, t is from 1 to 5, and s is from 0 to 3; and

wherein at least one of R^{13} , R^{14} , R^{15} or R^{16} comprise the hydroxyalkyl ether of Formula (IV).

38. The monomer of claim 37, wherein $m=0$, R^{13} is the hydroxy alkyl ether according to Formula (IVa), and R^{14} , R^{15} and R^{16} are each H.

39. The ethylenically unsaturated monomer of claim 38, wherein A is methylene or ethylene, each occurrence of R^{17} is H, and s is 0.

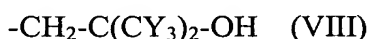
40. A polymer comprising repeat units derived from the monomer according to Formula (Ia) of claim 37.

41. A negative tone photoresist composition comprising:
A) a solvent;
B) a photosensitive acid generator;
C) a crosslinking agent containing one or more functional groups; and
D) one or more negative tone imaging polymers comprising the polymers according to claim 34, wherein the polymers contain one or more functional group containing moieties having a functional group that is reactive with the functional groups of the crosslinking agent.

42. The negative tone photoresist composition according to claim 41, wherein the negative tone imaging polymers are polymers according to claim 34 and the functional groups in the negative tone imaging polymers are selected from the group consisting of a hydroxy alkyl ether according to Formula (IV), where A, R^{35} , q and p are as defined; a group according to Formula (V), where R^{36} and Z are as defined; a group according to $-(CH_2)_n-C(CY_3)_2-OH$, where n and Y are as defined; a group according to $-(CH_2)_nC(O)OR^*$ where n and R^* are as defined; and a $-(CH_2)_z-C(CF_3)_2-O-(CH_2)_z-CO-(OR^{\#})$ group, where z is an integer from 1 to 6 and $R^{\#}$ is C_1-C_6 linear or branched alkyl.

43. The negative tone photoresist composition of claim 42, wherein $m=0$, R^1 is the hydroxy alkyl ether according to Formula (IV), and R^2 , R^3 , and R^4 are each H in the negative tone imaging polymers.

44. The negative tone photoresist composition of claim 42, wherein each of R^1 , R^2 , R^3 and R^4 are independently selected from H and a group according to Formula (VIII):



wherein Y is selected from F and Cl and at least one occurrence of Y is F and the negative tone imaging polymers are free of hydroxy alkyl ether according to Formula (IV).

45. The negative tone photoresist composition of claim 41, wherein the negative tone imaging polymer in (D) contains hydroxyl groups and the crosslinking agent (C) is a compound which is capable of reacting with the hydroxyl groups of the polymer in (D).

46. The negative tone photoresist composition of claim 41, wherein the crosslinking agent (C) is activated by an acid generated by the photosensitive acid generator (B).

47. The negative photoresist of claim 41, wherein the crosslinking agent (C) includes one or more compounds containing one or more groups selected from the group consisting of methylol, alkoxyalkyl and carboxymethyl group substituted phenols; methylol, alkoxyalkyl and carboxymethyl group substituted cyclic ureas; methylol, alkoxyalkyl and carboxymethyl group substituted melamines; and methylol, alkoxyalkyl and carboxymethyl group substituted benzoguanine compounds.

48. The negative photoresist of claim 38, wherein the photosensitive acid generator (B) is a compound that, upon exposure to radiation, generates a strong acid.

49. The negative photoresist of claim 41, wherein the photosensitive acid generator (B) includes one or more compounds selected from triflates, pyrogallols, onium salts, hexafluoroarsenates, trifluoromethanesulfonates, esters of hydroxyimides, α,α' -bis-sulfonyl-diazomethanes, sulfonate esters of nitro-substituted benzyl alcohols and naphthoquinone-4-diazides.

50. The negative photoresist of claim 49, wherein the triflates comprise triphenylsulfonium triflate; the pyrogallols comprise trimesylate of pyrogallol; and the onium salts comprise one or both of triarylsulfonium and diaryliodinium hexafluoroantimonates.

51. The negative photoresist of claim 38, wherein the solvent (A) comprises one or more solvents selected from the group consisting of propylene glycol methyl ether acetate, cyclohexanone, butyrolactate, and ethyl lactate.

52. A method of generating a negative tone resist image on a substrate comprising the steps of: (a) coating a substrate with a film comprising the negative tone photoresist composition of claim 41; (b) imagewise exposing the film to radiation to form an image; and (c) developing the image in the film where selected portions of the substrate are exposed.

53. The method of claim 52, wherein the substrate comprises one or more of silicon, ceramics and polymers.

54. The method of claim 51, wherein before the film has been exposed to radiation in (b), the film is heated to from 90°C to 150°C for from 30 seconds to 5 minutes.

55. The method of claim 52, wherein the film is imagewise exposed in (b) from a radiation source selected from mercury lamps, mercury/xenon lamps, xenon lamps, argon fluoride lasers, krypton fluoride lasers, x-rays and electron beams.

56. The method of claim 52, wherein the film is imagewise exposed in (b) at a wavelength of from 90 nm to 514 nm.

57. The method of claim 52, wherein after the film has been exposed to radiation, the film is heated to a temperature of from 90°C to 150°C for from 30 seconds to 5 minutes.

58. The method of claim 51, wherein the negative tone image is developed using one or more solvents selected from the group consisting of propylene glycol methyl ether acetate, cyclohexanone, butyrolactate, and ethyl lactate.

59. An integrated circuit assembly method comprising the steps of:

- (a) coating a substrate with the negative tone photoresist composition according to claim 41;
- (b) imagewise exposing the film to radiation to form an image;
- (c) developing the image in the film where selected portions of the substrate are exposed; and
- (d) transferring the developed image to the substrate.

60. An integrated circuit chip, multichip module, or circuit board comprising the integrated circuit provided by the method of claim 59.

61. The poly(cyclic)olefin polymer of claim 32, wherein the polymer has an optical density of less than 0.2 abs/ μm at an exposure wavelength of 193 nm.

62. A photoresist composition comprising the poly(cyclic olefin) polymer of claim 32.

63. The poly(cyclic)olefin polymer of claim 33, wherein the polymer has an optical density of less than 0.2 abs/ μm at an exposure wavelength of 193 nm.

64. A photoresist composition comprising the poly(cyclic olefin) polymer of claim 33.

65. The poly(cyclic)olefin polymer of claim 34, wherein the polymer has an optical density of less than 0.2 abs/ μ m at an exposure wavelength of 193 nm.

66. A photoresist composition comprising the poly(cyclic olefin) polymer of claim 34.

67. The poly(cyclic)olefin polymer of claim 35, wherein the polymer has an optical density of less than 0.2 abs/ μ m at an exposure wavelength of 193 nm.

68. A photoresist composition comprising the poly(cyclic olefin) polymer of claim 35.

69. A positive tone photoresist composition comprising

- (a) a solvent,
- (b) a photosensitive acid generator; and
- (c) and one or more positive tone imaging polymers comprising polymers according to claim 33, wherein the polymers contain a functional group containing moiety that contains a group that can be cleaved when exposed to radiation, rendering the polymer more soluble to a developer than the unexposed polymer.

70. A method of generating a positive tone resist image on a substrate comprising the steps of:

- (a) coating a substrate with a film comprising the positive tone photoresist composition of claim 69;
- (b) imagewise exposing the film to radiation to form an image; and
- (c) developing the image in the film where selected portions of the substrate are exposed.

71. The method of claim 70, wherein the substrate includes one or more of silicon, ceramics, and polymers.

72. The method of claim 70, wherein the film is coated on the substrate in using one or more methods selected from spin coating, spray coating and doctor blading.

73. The method of claim 70, wherein the film is imagewise exposed from a radiation source selected from mercury lamps, mercury/xenon lamps, xenon lamps, argon fluoride lasers, krypton fluoride lasers, fluorine lasers, x-rays and electron beams at a wavelength of from 90 nm to 514 nm.

74. The method of claim 70, wherein a solvent is used to develop the positive tone image and the solvent comprises an aqueous base.

75. An integrated circuit assembly method comprising the steps of:

- (a) coating a substrate with the positive tone photoresist composition according to claim 69;
- (b) imagewise exposing the film to radiation to form an image;
- (c) developing the image in the film where selected portions of the substrate are exposed; and
- (d) transferring the developed image to the substrate.